WATER QUALITY CRITERIA FOR NITROGEN
(NITRATE, NITRITE, AND AMMONIA)

MINISTRY OF ENVIRONMENT AND PARKS
PROVINCE OF BRITISH COLUMBIA

WATER QUALITY CRITERIA FOR NITROGEN (NITRATE, NITRITE, AND AMMONIA)

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Approved by Ministry: Nov 12, 1981
Date

Signature
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PREFACE

The Ministry of Environment and Parks is developing province-wide water quality criteria for characteristics that are important in the surface waters of British Columbia. This work has the following goals:

(i) to provide criteria for the evaluation of data on water, sediment, and biota for water quality assessments.

(ii) to provide criteria for the establishment of site-specific water quality objectives.

The water quality objectives for specific waterbodies will be based on the criteria as well as on present and future water uses, waste discharges, flow patterns, and water quality. The process for establishing water quality objectives is more fully outlined in "Principles for Preparing Water Quality Objectives in British Columbia", copies of which are available from the Water Management Branch.

The definition adopted for criterion is:

"A maximum and/or a minimum value for a physical, chemical, or biological characteristic of water, sediment, or biota, which must not be exceeded to prevent specified detrimental effects from occurring to a water use under specified environmental conditions".

The criteria are province-wide in application, but use-specific, and are being developed for the following water uses:

- Drinking, public water supply, and food processing*
- Aquatic life and wildlife
- Agriculture (livestock watering and irrigation)

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*For raw water sources prior to treatment (the responsibility for regulating the quality of domestic water as supplied by a water purveyor lies with the Ministry of Health).

- Recreation and aesthetics**
- Industrial (other than food processing)

Criteria from the literature and other jurisdictions are evaluated, and criteria are adopted or developed from this evaluation. Recognizing that criteria from the literature do not necessarily reflect adequately the effects of contaminants in all waterbodies, the criteria in this document should be interpreted as guidelines. Site-specific criteria may be developed in special cases where the province-wide criteria are judged to be inadequate.

If a waterbody has several water uses, then the criteria for the most sensitive water use will be considered for developing water quality objectives. For specific waterbodies, particular circumstances could lead to objectives which are either more or less stringent than the criteria.

The criteria will be subject to review and revision as new knowledge becomes available, or as other circumstances dictate.

**The Ministry of Health has the responsibility for regulating the use of public bathing beaches with respect to the public health aspects.

RECOMMENDED CRITERIA

These criteria are based on a detailed analysis given in a technical appendix and are summarized in Table 1. The criteria are consistent with the Canadian Water Quality Guidelines (CCREM Guidelines) issued by the Canadian Council of Resource and Environment Ministers (1986), except as noted.

Nitrate, nitrite, and ammonia are the major inorganic nitrogen compounds occurring in surface waters. There is little environmental information on other compounds, both inorganic and organic, which are minor constituents or do not appear to affect water uses. These are therefore not included in the report at this time.

DRINKING WATER (Includes Food Processing Water)

For drinking water, high nitrate concentrations have been identified as a problem for infants. Nitrate can be converted to nitrite which combines with hemoglobin in the blood to form methemoglobin which does not absorb oxygen. With reduced capacity of the blood to absorb oxygen, death from lack of oxygen can result. Many agencies have specified maximum acceptable concentrations for nitrate or nitrate plus nitrite in drinking water and there is a general concensus that 10 mg/L (as N) represents a level of adequate protection. This well established level is proposed as the criterion for nitrate in drinking water for British Columbia. There is also a general consensus with regard to nitrite among other agencies, and no recent scientific evidence to the contrary, that less than 1 mg/L nitrite (as N) represents a concentration which will provide protection against adverse effects in humans in drinking water supplies. The criterion for British Columbia which is proposed is a maximum of 1 mg/L nitrite (as N).

Establishing a criterion for ammonia in drinking water is more difficult. Although a number of other agencies have specified ammonia concentrations intended to provide acceptable drinking water, there now seems to be a

very poor basis for the concentrations proposed. There does not seem to be sufficient data to define an ammonia concentration at which problems such as taste and odour, interference with chlorine disinfection, or any health effects occur. Consequently, no criterion for ammonia in drinking water supplies is proposed.

AQUATIC LIFE (Freshwater, Marine, and Estuarine)

In the literature, there has been a much more detailed examination of the response to nitrate, nitrite, and ammonia by freshwater biota, particularly fish, than by marine biota. Studies concerning estuarine biota are almost totally absent. As a consequence, the data on which to base criteria are much better for freshwater than marine water. Since virtually no data exist for nitrogen toxicity in estuarine environments, no specific criteria are suggested. It is proposed that the more stringent of freshwater and marine criteria should be used for estuaries. For these criteria the maximum concentration is designed to protect aquatic life against acutely toxic effects and the 30-day average against chronic effects. The 30-day average should be calculated from at least five weekly samples.

For freshwater studies there has been different amounts of research into the aquatic toxicology of the three forms of nitrogen. Nitrate has been the subject of few investigations due to its relatively low toxicity. Based on the information available, a criterion of 200 mg/L (as N) is recommended for a maximum concentration and 40 mg/L as a thirty-day average. There are no CCREM Guidelines for nitrate for freshwater aquatic life.

Nitrite has been shown to be quite toxic to some groups of fish, particularly salmonids, and consequently more investigations have been done. On the basis of literature reports, a criterion of 0.020 mg/L (as N) is recommended as a mean concentration over a 30-day period for low chloride water, and a maximum concentration of 0.060 mg/L (as N) is recommended. Allowable concentrations increase with ambient concentrations of chloride, as shown in Table 2. The CCREM Guidelines specify a maximum of 0.06 mg/L for all chloride concentrations. The recommended criteria vary with chloride

concentration to reflect the marked influence of chloride on nitrite toxicity, and average criteria have also been recommended to provide adequate protection to the salmonids prevalent in British Columbia, particularly at low chloride concentrations.

Ammonia has been the subject of intensive investigation and there is thus an excellent background on which to base a criterion. Because ammonia has been investigated for a long period, increasingly sophisticated and accurate criteria are being derived. Ammonia criteria have evolved from a single value to tabular criteria relating toxicity to important physical or other interactive factors which affect toxicity. Two factors which are important to the toxicity of ammonia to aquatic organisms are the pH and temperature of the water environment. The pH and temperature affect the amount of un-ionized ammonia which is the form most toxic to aquatic life. The attached Tables 3 and 4 give the criteria recommended for maximum allowable concentrations of ammonia and for longer-term (30 day) allowable concentrations. These criteria are similar to those developed by the U.S. Environmental Protection Agency (EPA). The CCREM Guidelines adopted the EPA average criteria as maximum values, which in British Columbia's opinion is unnecessarily restrictive.

For marine studies, less information is available on which to base criteria. For nitrate and nitrite, insufficient data are available to propose any criteria. For ammonia, a maximum concentration of 2.5 mg/L (as N) and a 30-day average concentration of 1.0 mg/L (as N) are recommended. There are no CCREM Guidelines for marine aquatic life.

For estuarine conditions, the freshwater criteria apply. Increasing salinity decreases ammonia toxicity to a slight degree so some marginal additional protection is afforded.

IRRIGATION AND LIVESTOCK WATERING

Water with excessive amounts of ammonia may affect agricultural uses such as irrigation or water supplied to livestock. Insufficient information

is available to establish a criterion for nitrogen in irrigation water since an allowable concentration would be dependent on soil type, irrigation rate, and other factors. The proposed criteria for livestock watering exclude ammonia since few data exist. For nitrate or nitrate plus nitrite, a maximum concentration of 100 mg/L (as N) is recommended and for nitrite alone a maximum of 10 mg/L (as N). The same concentrations are recommended for waters which might be used by wildlife as a drinking water supply. There are no CCREM Guidelines for wildlife.

RECREATION AND AESTHETICS

This is a water use for which high concentrations of nitrate, nitrite or ammonia are not likely to cause any direct problems in terms of body contact or visual deterioration. The more likely problem would be eutrophication-related problems when high concentrations of nitrogen (and accompanying phosphorus) cause heavy accumulations of algae. However, to protect recreational users who may ingest water, it is recommended that the drinking water criteria should apply to waters used for recreation. There are no CCREM Guidelines for nitrogen for recreation.

APPLICATION OF CRITERIA

Most of the criteria proposed require no additional explanation for their use. However, the table of ammonia criteria values for evaluation of chronic toxicity (Table 4) does require additional explanation for its application. The designated sampling period is 30 days and it is intended that at least five samples would be obtained. In addition to ammonia, each sample must be measured for pH and temperature. The temperature is that of the water in the field, and the pH is the laboratory pH at the time of analysis, although field pH is also acceptable if truly accurate measurements can be obtained.

The average measured concentration is calculated as an arithmetic mean. Using the individual temperature and pH values, the corresponding criteria values are obtained from the table. A mean of these criteria values is

compared to the mean of the measured ammonia values. If the mean value for measured total ammonia exceeds the mean criteria value, the criteria would then be considered to be exceeded. If the mean value does not exceed the mean criteria value, it is still necessary to compare individual criteria to corresponding analytical results to ascertain whether or not more than 20% of the measured values exceed the mean criteria value by more than 150%. If more than 20% of the measured values do exceed the mean criteria by 150%, the criteria is exceeded even if the measured mean is less than the mean criteria value. This provision restricts the occurrence of fluctuating concentrations which can be more detrimental to aquatic life than a steady concentration.

TABLE 1

SUMMARY OF WATER QUALITY CRITERIA FOR NITROGEN

CHARACTERISTIC / WATER USE	Nitrate (mg/L as N)	Nitrite (mg/L as N)	Total Ammonia (mg/L as N)
Drinking Water	10* maximum	1 maximum	none proposed
Freshwater Aquatic life			see Tables 3 and 4
maximum	200	0.06	
average	≤40	≤0.02 chloride <2 mg/L also see Table 2	
Marine Aquatic life	none proposed	none proposed	
maximum			2.5
average			≤1.0
Livestock Watering	100* maximum	10 maximum	none proposed
Wildlife	100* maximum	10 maximum	none proposed
Recreation and Aesthetics	10* maximum	1 maximum	none proposed

The average value is calculated from at least 5 weekly samples taken in a period of 30 days.

* Where nitrate and nitrite are present, the total nitrate- plus nitrite-nitrogen should not exceed these values.

TABLE 2

CRITERIA FOR NITRITE FOR PROTECTION OF
FRESHWATER AQUATIC LIFE

Chloride Concentration (mg/L)	Maximum Nitrite Concentration (mg/L as N)	Average Nitrite Concentration* (mg/L as N)
less than 2	0.06	0.02
2-4	0.12	0.04
4-6	0.18	0.06
6-8	0.24	0.08
8-10	0.30	0.10
greater than 10	0.60	0.20

* the 30-d average chloride concentration should be used to determine the appropriate 30-d average nitrite criterion.

TABLE 3

MAXIMUM CONCENTRATION OF TOTAL AMMONIA NITROGEN FOR PROTECTION OF AQUATIC LIFE
(mg/L-N)

pH	Temp. 0.0	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
6.5	27.7	28.3	27.9	27.5	27.2	26.8	26.5	26.2	26.0	25.7	25.5
6.6	27.9	27.5	27.2	26.8	26.4	26.1	25.8	25.5	25.2	25.0	24.7
6.7	26.9	26.5	26.2	25.9	25.5	25.2	24.9	24.6	24.4	24.1	23.9
6.8	25.8	25.5	25.1	24.8	24.5	24.2	23.9	23.6	23.4	23.1	22.9
6.9	24.6	24.2	23.9	23.6	23.3	23.0	22.7	22.5	22.2	22.0	21.8
7.0	23.2	22.8	22.5	22.2	21.9	21.6	21.4	21.1	20.9	20.7	20.5
7.1	21.6	21.3	20.9	20.7	20.4	20.2	19.9	19.7	19.5	19.3	19.1
7.2	19.9	19.6	19.3	19.0	18.8	18.6	18.3	18.1	17.9	17.8	17.6
7.3	18.1	17.8	17.5	17.3	17.1	16.9	16.7	16.5	16.3	16.2	16.0
7.4	16.2	16.0	15.7	15.5	15.3	15.2	15.0	14.8	14.7	14.5	14.4
7.5	14.4	14.1	14.0	13.8	13.6	13.4	13.3	13.1	13.0	12.9	12.7
7.6	12.6	12.4	12.2	12.0	11.9	11.7	11.6	11.5	11.4	11.3	11.2
7.7	10.8	10.7	10.5	10.4	10.3	10.1	10.0	9.92	9.83	9.73	9.65
7.8	9.26	9.12	8.98	8.88	8.77	8.67	8.57	8.48	8.40	8.32	8.25
7.9	7.82	7.71	7.60	7.51	7.42	7.33	7.25	7.17	7.10	7.04	6.98
8.0	6.55	6.46	6.37	6.29	6.22	6.14	6.08	6.02	5.96	5.91	5.86
8.1	5.21	5.14	5.07	5.01	4.95	4.90	4.84	4.80	4.75	4.71	4.67
8.2	4.15	4.09	4.04	3.99	3.95	3.90	3.86	3.83	3.80	3.76	3.74
8.3	3.31	3.27	3.22	3.19	3.15	3.12	3.09	3.06	3.03	3.01	2.99
8.4	2.64	2.61	2.57	2.54	2.52	2.49	2.47	2.45	2.43	2.41	2.40
8.5	2.11	2.08	2.06	2.03	2.01	1.99	1.98	1.96	1.95	1.94	1.93
8.6	1.69	1.67	1.65	1.63	1.61	1.60	1.59	1.58	1.57	1.56	1.55
8.7	1.35	1.33	1.32	1.31	1.30	1.29	1.28	1.27	1.26	1.26	1.25
8.8	1.08	1.07	1.06	1.05	1.04	1.04	1.03	1.03	1.02	1.02	1.02
8.9	0.871	0.863	0.856	0.849	0.844	0.839	0.836	0.833	0.832	0.831	0.831
9.0	0.703	0.697	0.692	0.688	0.685	0.682	0.681	0.681	0.680	0.681	0.682

	11.0	12.0	13.0	14.0	15.0	16.0	17.0	18.0	19.0	20.0
6.5	25.2	25.0	24.8	24.6	24.5	24.3	24.2	24.0	23.9	23.8
6.6	24.5	24.3	24.1	23.9	23.8	24.6	23.5	23.3	23.3	23.2
6.7	23.7	23.5	23.3	23.1	23.0	22.8	22.7	22.6	22.5	22.4
6.8	22.7	22.5	22.3	22.2	22.0	21.9	21.8	21.7	21.6	21.5
6.9	21.6	21.4	21.3	21.1	21.0	20.8	20.7	20.6	20.5	20.4
7.0	20.3	20.2	20.0	19.9	19.7	19.6	19.5	19.4	19.3	19.2
7.1	18.9	18.8	18.7	18.5	18.4	18.3	18.2	18.1	18.0	17.9
7.2	17.4	17.3	17.2	17.1	16.9	16.8	16.8	16.7	16.6	16.5
7.3	15.9	15.7	15.6	15.5	15.4	15.3	15.2	15.2	15.1	15.1
7.4	14.2	14.1	14.0	13.9	13.9	13.8	13.7	13.6	13.6	13.5
7.5	12.6	12.5	12.4	12.4	12.3	12.2	12.2	12.1	12.1	12.0
7.6	11.1	11.0	10.9	10.8	10.8	10.7	10.7	10.6	10.6	10.5
7.7	9.57	9.50	9.43	9.37	9.31	9.26	9.22	9.81	9.15	9.12
7.8	8.18	8.12	8.07	8.02	7.97	7.93	7.90	7.87	7.84	7.82
7.9	6.92	6.88	6.83	6.79	6.75	6.72	6.69	6.67	6.65	6.64
8.0	5.81	5.78	5.74	5.71	5.68	5.66	5.64	5.62	5.61	5.60
8.1	4.64	4.61	4.59	4.56	4.54	4.53	4.51	4.50	4.49	4.49
8.2	3.71	3.69	3.67	3.65	3.64	3.63	3.62	3.61	3.61	3.61
8.3	2.97	2.96	2.94	2.93	2.92	2.92	2.91	2.91	2.91	2.91
8.4	2.38	2.37	2.36	2.36	2.35	2.35	2.35	2.35	2.35	2.36
8.5	1.92	1.91	1.91	1.90	1.90	1.90	1.90	1.90	1.91	1.92
8.6	1.55	1.54	1.54	1.54	1.54	1.54	1.55	1.55	1.56	1.57
8.7	1.25	1.25	1.25	1.25	1.25	1.26	1.26	1.27	1.28	1.29
8.8	1.02	1.11	1.02	1.02	1.03	1.03	1.04	1.05	1.06	1.07
8.9	0.832	0.834	0.838	0.842	0.847	0.853	0.861	0.870	0.880	0.891
9.0	0.684	0.688	0.692	0.698	0.704	0.711	0.720	0.729	0.740	0.752

TABLE 4

AVERAGE 30-DAY CONCENTRATION OF TOTAL AMMONIA NITROGEN FOR PROTECTION OF AQUATIC LIFE
(mg/L-N)

pH	Temp. 0.0	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
6.5	2.08	2.05	2.02	1.99	1.97	1.94	1.92	1.90	1.88	1.86	1.84
6.6	2.08	2.05	2.02	1.99	1.97	1.94	1.92	1.90	1.88	1.86	1.84
6.7	2.08	2.05	2.02	1.99	1.97	1.94	1.92	1.90	1.88	1.86	1.84
6.8	2.08	2.05	2.02	1.99	1.96	1.94	1.92	1.90	1.88	1.86	1.84
6.9	2.08	2.05	2.02	1.99	1.97	1.94	1.92	1.90	1.88	1.86	1.84
7.0	2.08	2.05	2.02	1.99	1.97	1.94	1.92	1.90	1.88	1.86	1.84
7.1	2.08	2.05	2.02	1.99	1.97	1.94	1.92	1.90	1.88	1.86	1.84
7.2	2.08	2.05	2.02	1.99	1.96	1.95	1.92	1.90	1.88	1.86	1.85
7.3	2.08	2.05	2.02	1.99	1.97	1.95	1.92	1.90	1.88	1.86	1.85
7.4	2.08	2.05	2.02	2.00	1.97	1.95	1.92	1.90	1.88	1.87	1.85
7.5	2.08	2.05	2.02	2.00	1.97	1.95	1.93	1.91	1.88	1.87	1.85
7.6	2.09	2.05	2.03	2.00	1.97	1.95	1.93	1.91	1.89	1.87	1.85
7.7	2.09	2.05	2.03	2.00	1.98	1.95	1.93	1.91	1.89	1.87	1.86
7.8	1.78	1.75	1.73	1.71	1.69	1.67	1.65	1.63	1.62	1.60	1.59
7.9	1.50	1.48	1.46	1.44	1.43	1.41	1.39	1.38	1.36	1.35	1.34
8.0	1.26	1.24	1.23	1.21	1.20	1.18	1.17	1.16	1.15	1.14	1.13
8.1	1.00	0.989	0.976	0.963	0.952	0.942	0.932	0.922	0.914	0.906	0.899
8.2	0.799	0.788	0.777	0.768	0.759	0.751	0.743	0.736	0.730	0.724	0.718
8.3	0.636	0.628	0.620	0.613	0.606	0.599	0.594	0.588	0.583	0.579	0.575
8.4	0.508	0.501	0.495	0.489	0.484	0.479	0.475	0.471	0.467	0.464	0.461
8.5	0.405	0.400	0.396	0.381	0.387	0.384	0.380	0.377	0.375	0.372	0.370
8.6	0.324	0.320	0.317	0.313	0.310	0.308	0.305	0.303	0.301	0.300	0.298
8.7	0.260	0.257	0.254	0.251	0.249	0.247	0.246	0.244	0.243	0.242	0.241
8.8	0.208	0.206	0.204	0.202	0.201	0.200	0.198	0.197	0.197	0.196	0.196
8.9	0.168	0.166	0.165	0.163	0.162	0.161	0.161	0.160	0.160	0.160	0.160
9.0	0.135	0.134	0.133	0.132	0.132	0.131	0.131	0.131	0.131	0.131	0.131

	11.0	12.0	13.0	14.0	15.0	16.0	17.0	18.0	19.0	20.0
6.5	1.82	1.81	1.80	1.78	1.77	1.64	1.52	1.41	1.31	1.22
6.6	1.82	1.81	1.80	1.78	1.77	1.64	1.52	1.41	1.31	1.22
6.7	1.83	1.81	1.80	1.78	1.77	1.64	1.52	1.41	1.31	1.22
6.8	1.83	1.81	1.80	1.78	1.77	1.64	1.52	1.42	1.32	1.22
6.9	1.82	1.81	1.80	1.78	1.77	1.64	1.53	1.42	1.32	1.22
7.0	1.83	1.81	1.80	1.79	1.77	1.64	1.53	1.42	1.32	1.22
7.1	1.83	1.81	1.80	1.79	1.77	1.65	1.53	1.42	1.32	1.23
7.2	1.83	1.81	1.80	1.79	1.78	1.65	1.53	1.42	1.32	1.23
7.3	1.83	1.82	1.80	1.79	1.78	1.65	1.53	1.42	1.32	1.23
7.4	1.83	1.82	1.80	1.79	1.78	1.65	1.53	1.42	1.32	1.23
7.5	1.83	1.82	1.81	1.80	1.78	1.66	1.54	1.43	1.33	1.23
7.6	1.84	1.82	1.81	1.80	1.79	1.66	1.54	1.43	1.33	1.24
7.7	1.84	1.83	1.81	1.80	1.79	1.66	1.54	1.44	1.34	1.24
7.8	1.57	1.56	1.55	1.54	1.53	1.42	1.32	1.23	1.14	1.07
7.9	1.33	1.32	1.31	1.31	1.30	1.21	1.12	1.04	0.970	0.904
8.0	1.12	1.11	1.10	1.10	1.09	1.02	0.944	0.878	0.818	0.762
8.1	0.893	0.887	0.882	0.878	0.874	0.812	0.756	0.704	0.655	0.611
8.2	0.714	0.709	0.706	0.703	0.700	0.651	0.606	0.565	0.527	0.491
8.3	0.571	0.568	0.566	0.564	0.562	0.523	0.487	0.455	0.424	0.396
8.4	0.458	0.456	0.455	0.453	0.452	0.421	0.393	0.367	0.343	0.321
8.5	0.369	0.367	0.366	0.366	0.365	0.341	0.318	0.298	0.278	0.261
8.6	0.297	0.297	0.296	0.296	0.296	0.277	0.259	0.242	0.227	0.213
8.7	0.241	0.240	0.240	0.241	0.241	0.226	0.212	0.198	0.186	0.175
8.8	0.196	0.196	0.196	0.197	0.198	0.185	0.174	0.164	0.154	0.145
8.9	0.160	0.161	0.161	0.162	0.163	0.153	0.144	0.136	0.128	0.121
9.0	0.132	0.132	0.133	0.134	0.135	0.128	0.121	0.114	0.108	0.102

- the average of the measured values must be less than the average of the corresponding individual values in Table 4.
- each measured value is compared to the corresponding individual values in Table 4. No more than one in five of the measured values can be greater than one-and-a-half times the corresponding criteria values in Table 4.

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